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Virtual Reality Museums: Redefining Engagement and Understanding in Cultural Heritage

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Abstract. This study explores the paradigm-shifting impact of Virtual Reality (VR) on museum experience design, using the banjo's rich history as a case study to explore these benefits, especially in regards to understanding and empathizing with African-American culture throughout time. This VR museum's design model not only enhances visitor engagement through interactive 3D models, videos, and virtual explorations, but also transcends the limitations of physical space, making the museum experience accessible to a global audience, so long as they have access to a VR headset. Our findings indicate that the educational quality of the VR museum matches—and in some aspects surpasses—that of traditional museums by providing immersive, interactive learning environments where visitors can deeply engage with the cultural and historical narratives of the banjo. Additionally, VR facilitates the easy customization and updating of exhibits, allowing for content that remains current and relevant. Most importantly, the VR setting offers a sensitive platform for presenting emotionally charged content, such as the banjo's connections to slavery and African American history, fostering a deeper cultural connection and understanding. This study demonstrates that VR technology can significantly transform museum experiences, making them more inclusive, educational, and emotionally engaging, thus redefining the standard museum design paradigm. While VR headsets are not yet widely accessible due to socioeconomic factors, addressing this challenge is beyond the scope of this paper.

Keywords: Virtual Reality, Museum Education, Social Awareness, Culture Engagement, Game for Learning.

1 Introduction

1.1 Technology Background

As digital technologies reshape cultural heritage engagement, Virtual Reality (VR) offers an innovative way to enhance museum experiences. VR museums provide personalized, immersive, and interactive access to historical and cultural artifacts globally [2]. This paper presents the VR banjo museum, a project that leverages VR to educate and engage users with the banjo's history—an instrument deeply rooted in African American heritage. By eliminating geographical barriers, the museum allows users to explore the banjo's evolution through interactive 3D models, videos, and virtual explorations, enhancing accessibility and educational impact [3,4].
The inspiration for this VR experience emerged when Kristina Gaddy [1] highlighted the banjo's history during a concert at The Metropolitan Museum of Art. Gaddy's work, "Well of Souls," underscores the banjo's connection to African American history, a narrative often overlooked. Musician Rhiannon Giddens admitted she had little knowledge of this history when she first learned to play the banjo, a sentiment shared by many musicians. Motivated by the need to preserve and share this cultural legacy, this VR museum was created to offer an engaging, educational experience that deepens appreciation for the banjo's historical significance.

1.2 Potential Challenges

Creating a virtual reality museum presents several challenges, including handling multimedia integration, adapting to VR headsets, and ensuring seamless navigation. Managing emotionally intense content is crucial, particularly when addressing sensitive historical topics. User comfort with technology and immersion remains a priority to maximize engagement and accessibility.

VR technology has been shown to enhance curiosity and learning outcomes in educational settings [5,6], making it an effective tool for fostering interest in the banjo's history and its cultural significance. Research by Doz et al. [7] supports VR's potential to stimulate curiosity and deepen learning experiences. User tests and interviews indicate strong engagement, with many visitors expressing interest in the banjo's origins and its historical ties to American slavery and the Black community. This topic holds particular relevance for audiences interested in music history, cultural studies, and social justice.

Exploring the resilience and creativity of Black musicians who shaped the banjo offers a powerful narrative of cultural preservation and artistic expression in the face of oppression. To prevent emotional overload, exhibitions outside the core collection provide non-guided experiences and moments of reflection, complemented by recent media content and engaging facts to balance education with entertainment [8]. Engaging with the banjo's history empowers the Black community by acknowledging their ancestors' contributions to American music while fostering cross-cultural appreciation and learning among visitors of diverse backgrounds [9,10].

1.3 Ideate Concept

Based on Parong and Mayer's [13] research, learning performance improves in multimedia learning environments, which guided the development of the VR museum as a fully immersive and interactive space. By curating images, text, 3D models, audio, and motion elements, the virtual museum simulates the spatial and sensory experiences of a real museum while ensuring smooth navigation and minimizing cognitive overload through iterative refinements (see Fig. 1). Accessibility is a key consideration, with the museum designed to function across different VR platforms and devices, supported by resources such as the Accessibility Virtual Reality YouTube channel and the open-source platform Spatial, which allows for gradual integration of accessibility features. Social significance is embedded in the experience through multimedia content that highlights the historical and cultural relevance of the banjo, using 3D models sourced from museum archives and historical references to enhance engagement while optimizing development costs (see Fig. 2). Additionally, the museum fosters emotional engagement through guided explorations and object-based learning, helping visitors gain a deeper understanding of the banjo's historical journey, significance, and broader cultural impact (see Fig. 3).

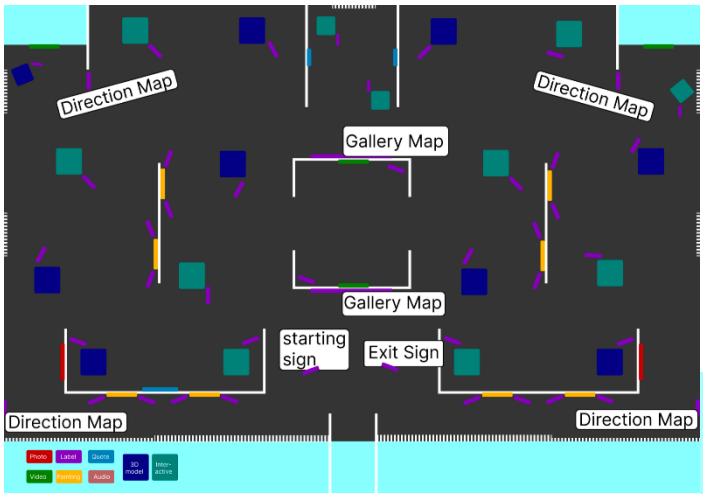

Fig. 1. Elements label in VR museum floor plan.

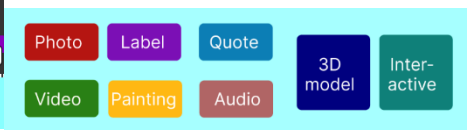

Fig. 2. VR museum floor plan with elements distribution.

2 Literature Review

Museums have long been informal learning institutions, showcasing artifacts to preserve culture and contribute to historical knowledge [17]. Traditionally, museums use spacious buildings to house exhibits, accompanied by text-based notes. To enhance visitor engagement, museum shave started incorporating audio and video elements and adopting digitization to offer virtual content accessible through websites.Museums have long served as informal learning spaces, preserving cultural heritage and historical knowledge [17]. Traditionally reliant on physical exhibits and text-based descriptions, museums have increasingly incorporated audio, video, and digital content to enhance visitor engagement. The rise of Virtual Reality (VR) has further transformed museums, offering immersive, interactive experiences that deepen understanding and expand accessibility [18]. The COVID-19 pandemic accelerated VR adoption, enabling remote and interactive educational experiences that complement traditional exhibits.

Case studies highlight VR's potential in museums. "On the Morning You Wake" demonstrated the emotional impact of VR storytelling, with Plass et al. [16] noting its enhanced engagement and learning compared to 2D experiences. Cheong et al. [17] studied a VR telecommunications exhibition in Malaysia, finding positive learning outcomes and high usability, though diversity in participation remains a challenge. Poce et al. [14] developed the E-Trouria App for an Etruscan museum, using digital storytelling to create personalized experiences, though soundtrack limitations were noted. Despite VR's promise in education [19], accessibility gaps persist, particularly for individuals with special needs. Future research should focus on inclusivity to maximize VR's potential in making museum experiences more equitable and engaging.

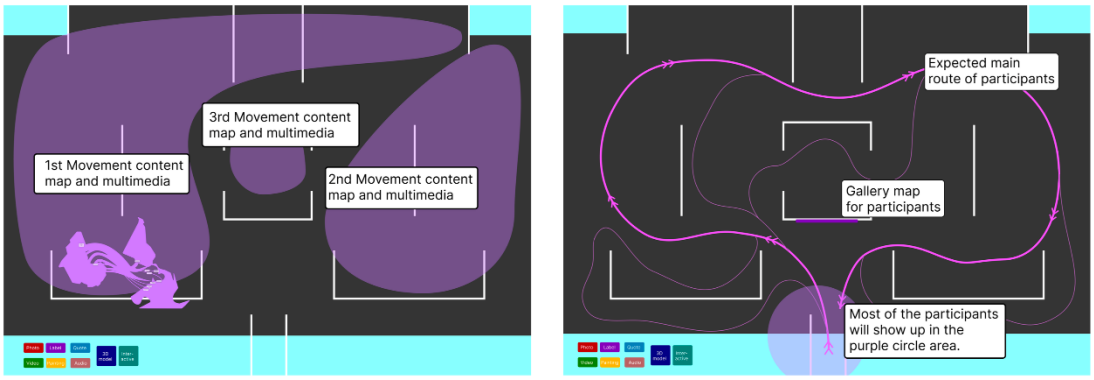

Fig. 3. VR museum floor map with content distribution and movement guidance.

3 Design Solution

Incorporating multimedia elements such as sound, images, and videos enhances public understanding of musical instruments. To achieve this, I assembled 3D models of various instruments (see Fig. 4), positioning descriptive screenshots and embedding videos to create interactive information capsules. This layout ensures effective content delivery while minimizing cognitive load. Recognizing the potential to visualize the instruments' historical development, I integrated maps onto the virtual floor, marking their chronological and geographical evolution. Guided by user-centered design principles [12], the VR museum is designed for seamless exploration and interaction, accessible via VR goggles or a web interface.

Users begin their experience by selecting avatars and completing platform training before exploring the museum. Notes are displayed next to 3D models, complemented by images and videos on virtual walls to enrich understanding. The inclusion of paintings featuring banjo elements (see Fig. 5) allows users to interact with historical evidence, immersing themselves in authentic settings that contextualize the instrument's origins and evolution. These paintings serve as enduring records of musical heritage, bridging past and present while catering to diverse learning preferences through both immersive and web-based experiences. At its core, the VR banjo museum faithfully recreates the instrument's journey, from its origins to modern usage, presented on a culturally sensitive and inclusive platform.

Fig. 4. VR museum multimedia display.

Fig. 5. Paintings featuring banjo elements.

3.1 Learner Characteristics

To better understand potential users, I adopted Falk's [15] classification of museum visitor types and applied activity theory to create three personas: Museum Enthusiast, Musician, and Activity Facilitator. These personas help tailor the VR museum experience to diverse visitor needs, ensuring accessibility, engagement, and educational impact. Through interviews and surveys, I gathered insights from musicians, museum professionals, and event facilitators. Musicians expressed interest in a banjo-focused experience, highlighting the importance of interactive and immersive elements. Museum enthusiasts, including educators and professionals, provided feedback on ideal virtual exhibitions, emphasizing historical context and engagement strategies. Event facilitators, influenced by socio-cultural expectations, shared perspectives on visitor engagement and accessibility. Their input shaped a VR museum experience that is interactive, inclusive, and culturally resonant, making the banjo's history more accessible and impactful for a wide audience (see Fig. 6).

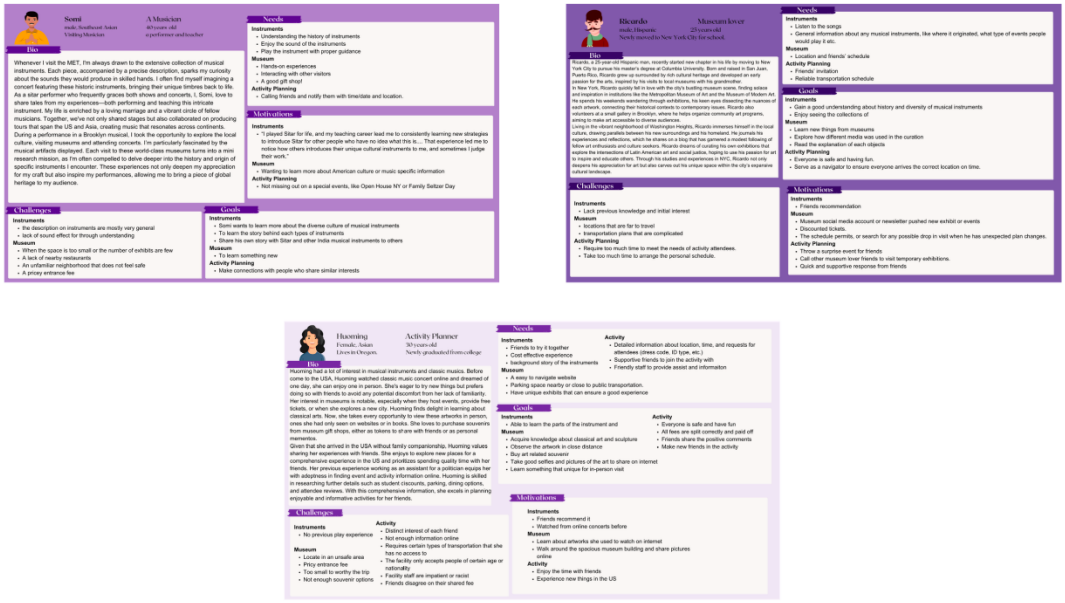

Fig. 6. Three personas for subject matter expert (upper left), museum enthusiastic (upper right), and activity facilitator (bottom middle).

4 User Testing

4.1 Testing Research Plan

To better understand and serve the participants, I conducted user testing to evaluate the acceptance of the VR technology and the effectiveness of the VR museum in helping participants gain knowledge of banjo history. I utilized the thinking-aloud protocol and user interviews to gather feedback from New York University students and community members.

Tasks:

1. Create your own avatar in Spatial [20].

2. Find the content for New York, 1736.
3. Tell me what you learned from the current virtual reality experience.

User Feedback: Participants found the avatar creation process engaging and navigated the virtual space with ease. They expressed interest and empathy towards the banjo's history, with some suggesting the addition of background music and vocal explanations to enhance the experience.

4.2 Design Iteration

With the valuable feedback from participants and subject matter experts, I improved the project for better user experience. By display interactive 3D models in the virtual space, I expect the participants can better focus on the historical content while interact with the models. I also modified the design style to ensure clear signage for a smooth experience flow, alongside with a self-paced vocal guide.

5 Conclusion

The VR banjo museum demonstrates how virtual reality can revolutionize museum experiences by offering an immersive, engaging, and educational platform. By integrating 3D models, paintings, videos, and interactive content, it enhances the exploration of the banjo's historical and cultural significance while addressing traditional museum challenges like exhibit separation and cognitive load. Leveraging VR technology, the museum fosters deeper understanding through open exploration.

User-centered design played a key role in development, ensuring accessibility and engagement through musician interviews, historical narratives, and interactive elements. The project highlights the importance of continuous updates and educational theories to enhance learning experiences. This VR museum serves as a scalable model for preserving and sharing cultural heritage, providing enriching and emotionally resonant experiences for diverse audiences. As VR technology advances, future research can further refine accessibility and engagement, expanding its impact on museum education.

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